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Optimized Dispersion Mapping Scheme for five channel WDM system

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Abstract- This paper investigates the optimum dispersion mapping for 40Gbps WDM system. The paper shows the performance of five channel WDM system with the channel spacing of 100GHz (0.8nm) by using non-zero dispersion shifted fiber (NZDSF) and dispersion compensation fiber (DCF). In addition it reveals both pre-compensation and residual dispersion per span can develop the performance. The modulation format used is RZ with 33% duty cycle. The optimum dispersion mappings for different channel numbers are discussed with different residual dispersions. By applying the optimum dispersion mapping, the impairments in the system can be minimized effectively .The analysis is done with OptiSystem software.

Index Terms- cross-phase modulation (XPM), dispersion compensation fiber (DCF), non-zero dispersion fiber (NZDSF), wavelength division multiplexing (WDM), residual dispersion

I. INTRODUCTION

The demand is growing to transmit the optical signals with high speed and to get the longer distance efficiently in order to fulfill today's requirements. The main impairment in the optical transmission link which may encounter is dispersion. This is due to the different frequency (wavelength) components contained in signals can have different propagation speeds so they reach the destination at different times. As a result, the pulse of signal is broadened and the received signal is distorted which is called dispersion because of the index variations rely on the wavelength. In WDM links, there is another degradation known as nonlinear effects. In this paper, the cross-phase modulation (XPM) effect is only considered. Cross phase modulation (XPM) appears as an optical signal's intensity variation which can cause Kerr effect and the phase modulation of other signals cooperating in the same fiber. There are many way to minimize transmission impairments. Dispersion compensation and management can be divided as: dispersion compensation fiber (DCF), chirped Bragg gratings (FBG) and high-order mode (HOM) fiber. Studies have shown different dispersion mapping in WDM systems and single channel ones. The optimal dispersion mapping in 10Gbps WDM system with SSMF has been analyzed [1]. There are also studies by using pre-compensation, post-compensation and symmetric compensation [2-3]. Some paper used different modulation formats within the same system [4].There are also researches with different fibers to compare different results during the same system configuration [5]. Among them to increase system performance dispersion mapping is needed to employ. It is easy and compatible to install. By making optimum dispersion mapping, pre-compensation and residual dispersion per span can suppress the impairments. This paper examines the performance of center channel (1550 nm) by optimizing dispersion mapping schemes. Non-zero dispersion shifted fiber (NZDSF) with typical dispersion of 4.5ps/nm.km is used as transmission fiber and dispersion compensation fiber, and EDFA are applied in the span for simulation. Dispersion mapping for WDM system is more difficult than that of single channel system due to XPM.

II. SYSTEM MODELLING AND DESCRIPTION OF DISPERSION MAPPING

A. Basic Principle of Dispersion Mapping

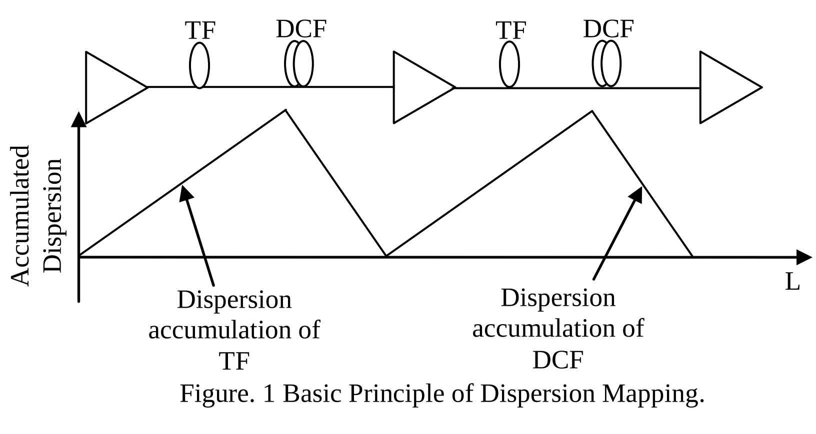

Figure. 1 Basic Principle of Dispersion Mapping.

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Dispersion mapping (dispersion management) is a method of eliminating dispersion of the system by implying two different fiber which have opposite dispersion values (negative and positive). When the signal is transmitted into the fiber, the distortion appears due to dispersion and nonlinear effects of the fiber. So the degraded signal must be done to maintain the original signal. To minimize the signal distortion, the fibers must have opposite dispersion values. By applying this method, dispersion can be eliminated sufficiently.

B. Residual Dispersion

The residual dispersion does not support the system performance normally. But nonlinear effect (XPM) in WDM system can be mitigated by applying residual dispersion because it will occur the delay between the signal pulses. According to the result, when the time slots of the signals are different, the XPM effect decreases. Therefore, residual dispersion in WDM system can increase the system performance. The net residual dispersion per span can be calculated by the following-

$$NRDPS = L_{NZDSF}D_{NZDSF} + L_{DCF}D_{DCF} \tag{1}$$

where L_{NZDSF} is the length of NZDSF, L_{DCF} is the length of DCF for all span, D_{NZDSF} is the NZDSF dispersion and D_{DCF} is the DCF dispersion.

III. SIMULATION OF DISPERSION MAPPING IN WDM SYSTEM

A. System configuration of the proposed system

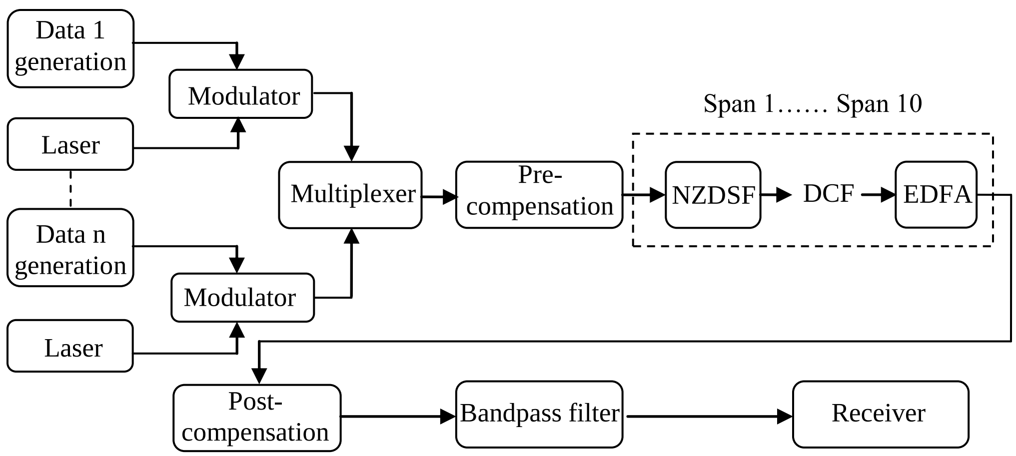


Figure. 2 Block diagram of the proposed system.

Figure. 2 shows the system configuration of the optimized dispersion mapping scheme for WDM system. This paper analyzes five 40Gbps RZ channels with 33% duty cycle are modulated by Mach-Zehnder modulators. These channels are multiplexed with wavelength division multiplexer (MUX). The wavelengths of the channels are between 1548.4nm and 1551.6nm and the channel spacing of 100GHz (0.8nm). The span consists of inline dispersion compensation fiber (DCF), non-zero dispersion shifted fiber (NZDSF) and an erbium-doped fiber amplifier (EDFA), the span number is 10. The dimensions used in this proposed system: L_{NZDSF}=100km, D_{NZDSF}=4.5ps/nm.km, α=0.21dB/km and γ=1.32/W/km. The loss is not considered in the inline DCF, pre-compensation and post-compensation. The inline EDFA is set to be 21dB gain to recover the loss. The total dispersion of the link is exactly eliminated at the receiver end. The center signal is obtained by using the optical Gaussian band-pass filter with a bandwidth of 80GHz. A fifth order optical receiver with 30GHz bandwidth is applied. The system performance is defined in terms of pre-compensation required to obtain a 10^{-9} BER.

B. Simulation Results and Discussion

Figure. 3 illustrates simulation setup for the optimized dispersion mapping scheme for five channel WDM system by using OptiSystem software. By applying residual dispersion of D_{res}=0, 10, 20, 30 and 40ps/nm per span, different dispersion mappings are investigated. The impairments in the system are calculated by using the BER versus different pre-compensation. In a single channel system, dispersion mapping can be performed easily as cross phase modulation (XPM) effect does not exist. The signal degradation in WDM system is worse than that of a single channel transmission link since the impact of XPM occurs. To make the comparisons, the simulation is carried out with the systems made up of the channel number of single, three and five as shown in figure. 4. The inline residual dispersion can increase the impairments without optimizing with pre-compensation. So there are the same results for residual dispersions. The impairments can be suppressed effectively by introducing pre-compensation and residual dispersion. The system performance is better when residual dispersion is increased. But the system performance difference is very small for D_{res}=30 and 40. The system suffers more degradation at large residual dispersion but the better BER is obtained due to residual dispersion increases as shown in figure. 5. In the proposed paper, the impairments are canceled by inline residual dispersion.

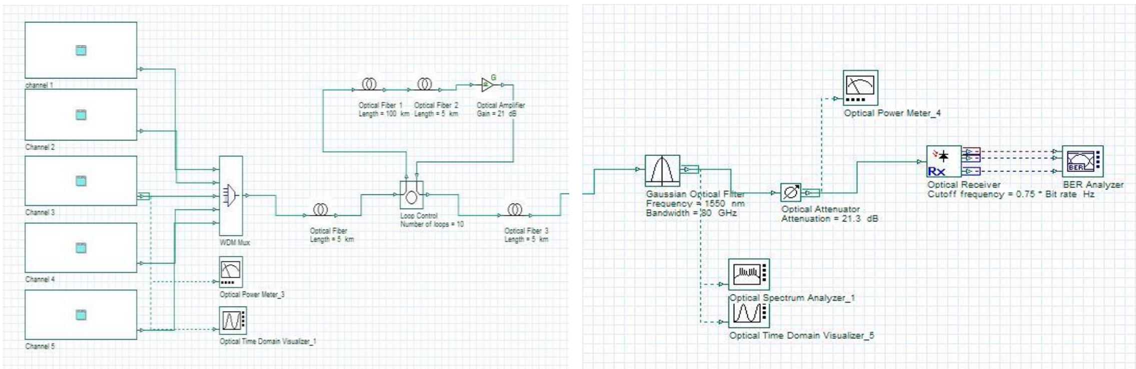
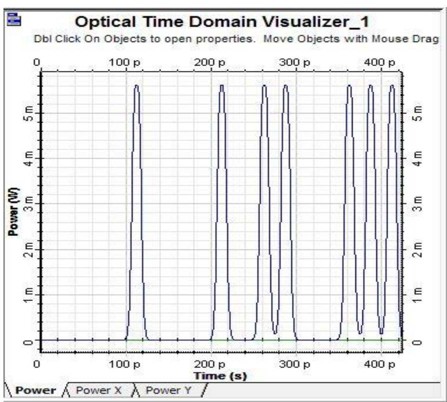
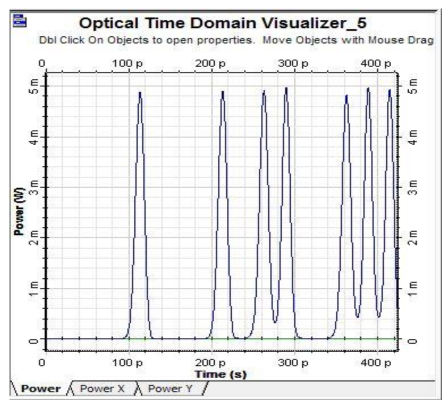


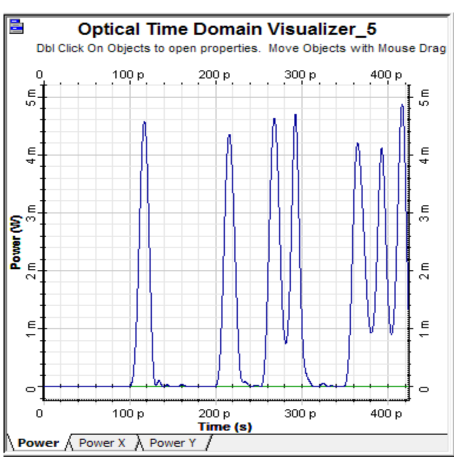
Fig. 3 Simulation setup for the optimized dispersion mapping of five channel WDM system.



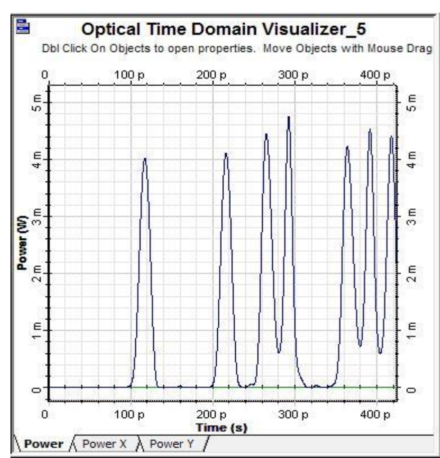
(a)



(b)

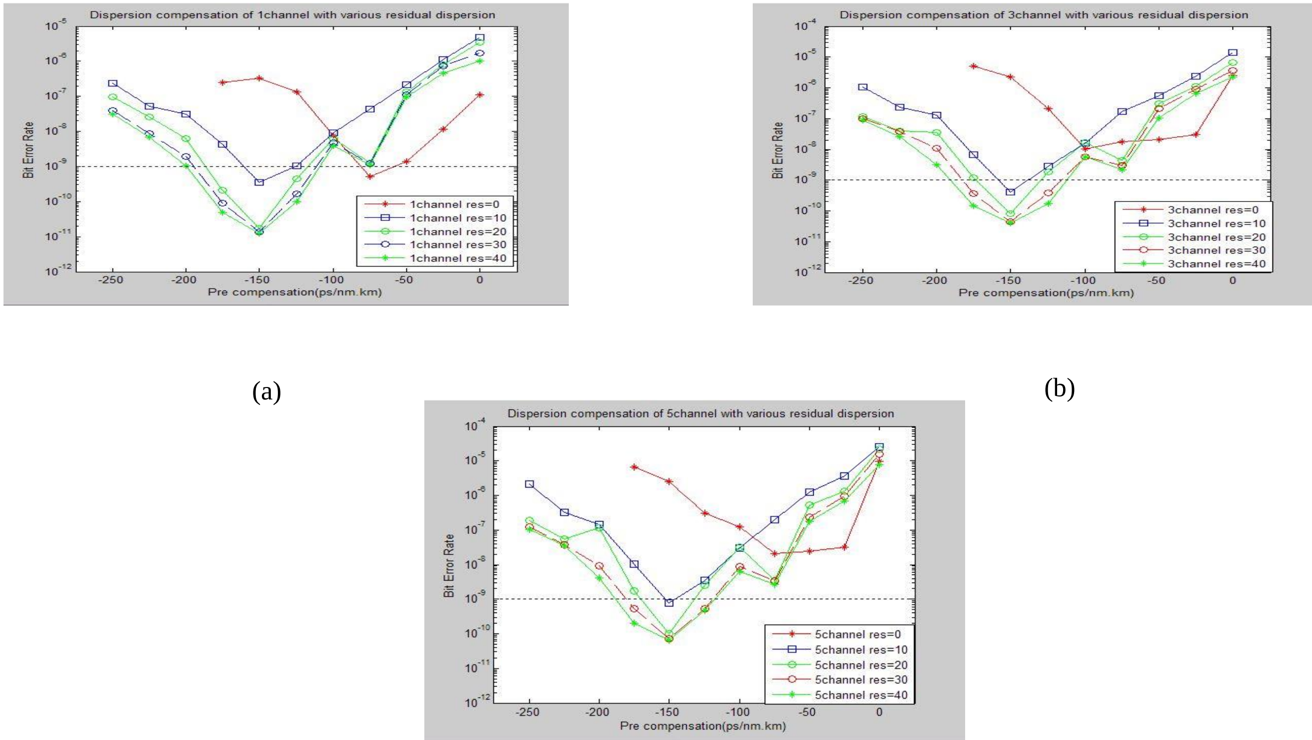


(c)



(d)

Figure. 4 The waveforms of the system (a) Input signal (b) Output of 1channel system
(c) Output of 3 channel system and (d) Output of 5 channel system .



(a) (b)

(c)

Figure . 5 BER curve of dispersion mapping (a) 1 channel (b) 3 channel and (c) 5 channel.

IV. CONCLUSION

The optimum dispersion mapping for 40Gbps RZ WDM systems which is affected by cross phase modulation (XPM) have investigated. Residual dispersion per span and pre-compensation can minimize the distortion. By conducting an optimum dispersion mapping, the impairment can be suppressed effectively. From the simulation results, the system performance will improve with more residual dispersion per span.

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